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THE VARIATIONS OF GLACIERS. XV¹

HARRY FIELDING REID
Johns Hopkins University

The following is a summary of the *Fourteenth Annual Report* of the International Committee on Glaciers.²

REPORT OF GLACIERS FOR 1908

Swiss Alps.—Of the ninety glaciers which were measured in 1908, fifty-three are in undoubted or probable retreat, one is certainly advancing, and thirteen are possibly advancing. The retreat, therefore, is general. Certain small glaciers have for some years shown signs, more or less definite, of advance. Short glaciers respond more quickly than long ones to the changes in snow-fall, and may make a number of small variations which are not indicated by large glaciers.³

Eastern Alps.—A large part of the observations on the glaciers of the Eastern Alps were carried out under the auspices and at the expense of the German and Austrian Alpine Club.

The general retreat was dominant between 1907 and 1908, as it has been for several years past. Only a single glacier, the Wanseeferner, in the Oztetal, has advanced; its advance amounted to 15 meters. The other glaciers showed retreats amounting in some cases to 23 meters.⁴

Italian Alps.—The observations of the Italian glaciers were all the results of private enterprise. All the glaciers observed on the south side of the Alps were apparently in retreat, except possibly a few in the Maritime Alps, which, seen from a distance, had apparently enlarged slightly; but this observation is doubtful.⁵

French Alps.—Many observations on the snow-fall and varia-

¹ The earlier reports appeared in the *Journal of Geology*, Vols. III-XVII.

² *Zeitschrift für Gletscherkunde* (1910), IV, 161-76.

³ Report of Professor Forel and M. Muret.

⁴ Report of Professor Brückner.

⁵ Report of Professor Marinelli.

tions of glaciers were made under the direction of the Minister of Agriculture.

During the winter of 1907-8, the amount of snow-fall was registered in twenty-seven stations in Savoy; although the snow-fall was less than in the previous year, still the total amount was fairly large. The maximum does not increase with the altitude, as the altitude becomes high; but the observations along this line are still incomplete.

On Mont Blanc the Glacier de Bionnassay, which between 1906 and 1907 had advanced 38 meters, in 1907-8 advanced 17.5 meters farther. The three other glaciers observed in this region had all retreated. The retreat of the Glacier du Tour amounted to 52.5 meters. In the Maurienne three small contiguous glaciers made a slight advance; a fourth glacier, not far distant, had retreated markedly.¹

Pyrenees.—A number of glaciers observed in this region showed a tendency to a slight advance.¹

Swedish Alps.—The retreat of the glaciers of Lapland, noticed since 1900, has been confirmed. During the summer of 1908 signals were placed near many glaciers which will lead to more definite results in the future.

Norwegian Alps.—The glaciers of the Jotenheim are in marked retreat, whereas those of the Jostedal and Folgenfon, nearer the coast, show an equally marked advance, the variations between 1907 and 1908 amounting in some cases to about 30 meters.²

Canada.—The Illecillewaet Glacier retreated about 40 feet between 1907 and 1908.³

Himalaya.—Although no new observations have been made, there are indications that since the survey of 1872-75 the glaciers of Garhwal and Kashmir have retreated considerably.⁴

REPORT OF THE GLACIERS OF THE UNITED STATES FOR 1909⁵

Hallett Glacier, Colorado, shows no change between 1908 and 1909 (Mills).

¹ Report of M. Rabot.

³ Report of Mr. Vaux.

² Report of M. Oyen.

⁴ Report of Mr. Freshfield.

⁵ A synopsis of this report will appear in the *Fifteenth Annual Report* of the International Committee. The report on the glaciers of the United States for the year 1908 was given in this *Journal* (XVII, No. 7, pp. 667-71).

The glaciers of Mt. Hood, Oregon, show a marked recession since 1906 and they have also decreased in thickness. The White Glacier has receded about 400 meters; Sandy Glacier 100 to 200 meters; Reid Glacier 50 to 100 meters, and Zig-Zag is hardly more than an ice-bank. The glaciers on the north side of the mountain, as seen from the summit, also seemed reduced in size (Montgomery).

Lyman Glacier, near Lake Chelan in central Washington, is still diminishing (Rusk).

Mt. Baker, Washington, the most northerly of the great volcanic cones which rise above the Cascade Range, was surveyed during the summer of 1909 by the United States Geological Survey, the party being under the direction of Mr. J. E. Blackburn. Mt. Baker, 10,745 feet high, is covered with ice and snow above an altitude of 5,000 feet, divided into a few separate masses by narrow ridges of rock.

At the lower levels glacier tongues develop, some of which extend to as low an altitude as 3,500 feet. Seven glaciers have been given names, the Roosevelt, Mazama, Wells Creek, Sholes, Park, Boulder Creek, and Nooksack. The last has not been fully explored and may later be divided and receive several names. The ice of these glaciers is especially broken up by large and numerous crevasses. The crater of the mountain, from which steam is still escaping, is about 1,000 feet below the flat snow-covered summit. The moraines in front of the glaciers' ends and the polished and grooved rock along their sides show clearly that they are retreating and diminishing in volume.

Fifteen miles northeast of Mt. Baker rises the spire of Mt. Shuksan, 9,038 feet; a glacier on its western side breaks over a cliff and the ice collects to form a reconstructed glacier at a lower level; this glacier then falls over a second cliff and forms a second reconstructed glacier still lower down (Blackburn).

The United States Coast and Geodetic Survey has published a map of Glacier Bay, and the surrounding area, on a scale of 1/160,000, from surveys made in 1907.¹ It is interesting to compare this map with the earlier one published by the survey in 1899.² The

¹ It is numbered 8306 and was published in January, 1910.

² No. 3095.

latter was based on surveys made by Reid in 1892, with additions taken from the surveys of the United States Coast and Geodetic Survey and of the Canadian Boundary Commission between 1884 and 1895. At the first glance one is struck by the smaller area covered by the ice, and the correspondingly greater area of bare rock; for instance, the ridge between Casement and McBride glaciers was broken in the earlier map by many arms of ice connecting the two glaciers; the later map shows this ridge as continuous and much broadened. Similar changes are noted in other parts of the map. This indicates not merely the melting of small connecting arms of ice, but also a general lowering of the whole surface of the ice. Dying Glacier at the head of Tidal Inlet has entirely disappeared, and Dirt Glacier, immediately east of Muir Inlet, is not represented on the later map. I am inclined to think that this glacier has not completely melted, but that its very thick covering of moraine has masked its character. Large areas of rock are free of the ice which covered them in 1892.

The ends of the tide-water glaciers have receded greatly (as noted in earlier reports of this series) and allowed the inlets to penetrate farther into the land.

The end of Muir Glacier has receded and divided into two parts, separated by the rocky island which appeared as two distinct nunataks in 1892 about 3 miles from the ice-front. To the north the glacier has receded 8.5 miles. The ice surrounds the water on three sides; bergs are discharged most actively at the northern end of the inlet. To the east the glacier has receded 3 miles and ends in a sloping surface just reaching the water. (Since 1907 this portion has receded still farther and now rests on a sandy beach, where it is forming a terminal moraine Dunann.)

The total increase in the area of the inlet between 1892 and 1907 was 19 square miles.

Carroll Glacier does not seem to have receded, but the Rendu has retreated about half a mile. Grand Pacific Glacier has receded $7\frac{1}{2}$ miles, almost as much as the Muir, and its inlet has increased by 14 square miles. Johns Hopkins has receded 3 miles, increasing its inlet by $5\frac{1}{2}$ square miles, and separating from one of its southern

tributaries, which becomes an independent tide-water glacier. Reid Glacier seems to have receded about $\frac{2}{3}$ mile.

In 1892 Hugh Miller Glacier attained tide-level at two termini; one, on the north, barely reached the water and had a sloping surface; this has retreated about half a mile. The other terminus, on the east, was divided by a rocky mass, north of which the ice resembled the northern terminus but south of which it ended in a cliff discharging bergs. The northern part of this terminus has receded about one mile and has uncovered much rock, about $1\frac{3}{4}$ square miles; the southern part has receded about $1\frac{1}{2}$ miles and the inlet has increased by about 2 square miles. Charpentier Glacier has receded about $1\frac{1}{2}$ miles and its inlet has increased by one square mile. Geikie Glacier has receded about $\frac{3}{4}$ mile and Wood Glacier has greatly diminished in size, though it still seems to reach tide-water as in 1892 without an ice cliff. The total increase in the area of Glacier Bay, as the result of the recession of the glaciers, amounts to about 50 square miles.

Professor Ralph S. Tarr has published a detailed account of the Yakutat Bay Glaciers, with many illustrations and maps, which includes all information regarding these glaciers available at the end of 1906.¹ The remarkable advance of some of these glaciers in the interval between Professor Tarr's visits to them in 1905 and 1906 are carefully considered and ascribed to extraordinary supplies of snow shaken down from the mountains by earthquakes in 1899.² This very excellent monograph can receive only a cursory notice here. Professors Tarr and Lawrence Martin organized an expedition under the auspices of the National Geographic Society to revisit Yakutat Bay and Prince William Sound in 1909. Professor Martin has sent me the following outlines of the results of this expedition:

The National Geographic Society's Alaskan Expedition of 1909 in charge of R. S. Tarr and Lawrence Martin observed the following variations of glaciers.

In Yakutat Bay Hubbard Glacier seemed to be beginning to advance more

¹ "The Yakutat Bay Region, Alaska," *U.S. Geological Survey, Professional Paper No. 64*, Washington, 1909.

² Mentioned in an earlier report of this series (this *Journal* [1908], XVI, 54-55).

rapidly; Lucia Glacier was advancing rapidly and overriding a nunatak after semi-stagnation since before 1890; Hidden Glacier had advanced 3 kms. in less than 3 years and had returned to semi-stagnation; Nunatak Glacier was continuing the retreat in progress since 1890, having retreated over $\frac{3}{4}$ km. since 1906 or nearly $5\frac{1}{2}$ kms. since 1895; Turner Glacier had advanced slightly since 1906. The Variegated, Haenke, Atrevida, and the Marvine lobe of Malaspina Glacier had ceased the spasmodic advance which Tarr observed in 1906 and explained, not as climatic, but as part of a glacier flood due to earthquake avalanching. Haenke Glacier, which advanced and became tidal between September, 1905 and June, 1906, had retreated before 1909 so that it no longer discharged icebergs, being fronted by a low gravel cliff. It was once more mantled with ablation moraine, as were large parts of Variegated and Atrevida glaciers and the Marvine lobe of Malaspina Glacier. Our party easily crossed Variegated and Atrevida Glaciers in 1909 in the parts most impassably crevassed in 1906. The advance of three additional glaciers between 1906 and 1909 and the quick return to semi-stagnation in 1909 of the four that were rapidly advancing in 1906 gives additional proof of the earthquake-avalanche hypothesis for certain variations of mountain glaciers.

On the lower Copper River the Miles, Childs, and Baird glaciers were, in 1909, in about the same conditions as when they were seen by Abercrombie in 1884, by Allen in 1885, by Hayes in 1891, and by Schrader in 1900. Parts of Miles and Baird glaciers have been stagnant and forest-covered for at least twenty-five years. Five miles of railway track has been laid on Baird Glacier. Childs Glacier seems to be advancing and forcing Copper River eastward, according to Johnson. The rate of movement near its northern margin in July, 1909 was about 4 feet a day. During the last half of July, 1909, ablation lowered the surface of Childs Glacier at the rate of 7 inches a day.

In eastern Prince William Sound, Valdez Glacier is retreating, as it has been since 1898 excepting the slight advance between 1905 and 1908 recorded by Grant. Shoup Glacier has been retreating since 1898 except for a slight advance, perhaps, in the spring of 1909. Columbia Glacier was continuing the advance observed by Grant in 1908 and early in July, 1909. The eastern margin had advanced, before August, 1909, making a decided lobation, but not reaching the forest along the whole margin. The western margin had advanced more than 800 feet up to the forest of Gilbert's maximum of 1892, as was also the case at Heather Island where the middle of the glacier was destroying the forest in August, 1909.

The United States Geological Survey has published a bulletin¹ containing a short account of the glaciers of the Wrangell

¹ F. H. Moffit and Adolph Knopf, "The Mineral Resources of the Nabesna-White River District, Alaska, with a Section on the Quaternary by S. R. Capps," *U.S. Geol. Survey, Bull. No. 417*, Washington, 1910.

Mountains, Alaska, and a topographic map of the region; and from it we draw the following information:

A very important feature of the Wrangell Mountains is the great ice cap that occupies the crest of the range and that has its greatest development in the region around Mount Wrangell. From the periphery of this great feeding ground valley glaciers extend in all directions down the more important drainage lines.

The Nabesna and the Chisana are by far the largest of these glaciers. The former is about 55 miles long and has an area of about 400 square miles. The latter is 30 miles long with an area of 135 square miles. There are many smaller ice tongues, and even small glaciers independent of the main ice cap.

The St. Elias Mountains, south of White River, are snow-capped in much the same way as the Wrangell Mountains. Most of the mountain range is unexplored, however, and the extent and area of the ice field is unknown. All the more important tributary valleys to the north are occupied by valley glaciers, the largest and best known of which is the Russell Glacier, at the head of White River. The main lobe of ice in the head of the White Valley is between 6 and 7 miles long and about $2\frac{1}{2}$ miles wide, and most of the ice moves in a northeast direction. A small crescentic lobe, however, moves westward into the head of Skolai Creek.

Formerly the glaciation was much more extensive, but very little information is available to determine what changes are taking place at present. In 1891 the western terminus of Russell Glacier was a smooth slope, but in 1909 it was a wall of ice from 25 to 75 feet high. This certainly indicates an advance of the ice, but at the northeastern terminus the ice passes into the moraine without a clear line of demarkation, indicating a slow, gradual retreat. The Nizana Glacier was formerly crossed by prospectors going to the White River region, but it has become so crevassed as to be practically impassable, which suggests an advance of the ice.